Hess's law

- Hess's Law states that the heat of a whole reaction is equivalent to the sum of it's steps.
- For example: $C + O_2 \rightarrow CO_2$ (pg. 165)

The book tells us that this can occur as 2 steps

$C + \frac{1}{2}O_2 \rightarrow CO$ $\quad \Delta H° = -110.5$ kJ

$CO + \frac{1}{2}O_2 \rightarrow CO_2$ $\quad \Delta H° = -283.0$ kJ

$C + \cancel{CO} + O_2 \rightarrow \cancel{CO} + CO_2$ $\quad \Delta H° = -393.5$ kJ

I.e. $C + O_2 \rightarrow CO_2$ $\quad \Delta H° = -393.5$ kJ

- Hess's law allows us to add equations.
- We add all reactants, products, & $\Delta H°$ values.
- We can also show how these steps add together via an "enthalpy diagram" …

Steps in drawing enthalpy diagrams

1. Balance the equation(s).
2. Sketch a rough draft based on $\Delta H°$ values.
3. Draw the overall chemical reaction as an enthalpy diagram (with the reactants on one line, and the products on the other line).
4. Draw a reaction representing the intermediate step by placing the relevant reactants on a line.
5. Check arrows: Start: two leading away
   Finish: two pointing to finish
   Intermediate: one to, one away
6. Look at equations to help complete balancing (all levels must have the same # of all atoms).
7. Add axes and $\Delta H°$ values.

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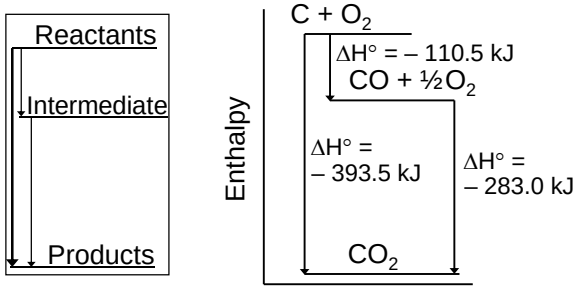
$C + O_2 \rightarrow CO_2$ $\quad \Delta H° = -393.5$ kJ



Note: states such as (s) and (g) have been ignored to reduce clutter on these slides. You should include these in your work.

Practice Exercise 6 (pg. 167) with Diagram

Using example 5.6 as a model, try PE 6.
Draw the related enthalpy diagram.

5.51 (pg. 175)

5.52 (pg. 175)

Hess's law: Example 5.7 (pg. 166)

We may need to manipulate equations further:

$2Fe + 1.5O_2 \rightarrow Fe_2O_3$ $\quad$ **$\Delta H°$=?**, given

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ $\quad \Delta H° = -26.74$ kJ

$CO + \frac{1}{2}O_2 \rightarrow CO_2$ $\quad \Delta H° = -282.96$ kJ

1: Align equations based on reactants/products.
2: Multiply based on final reaction.
3: Add equations.

$2Fe + \cancel{3CO_2} \rightarrow Fe_2O_3 + \cancel{3CO}$ $\quad \Delta H° = +26.74$ kJ

$\cancel{CO + \frac{1}{2}O_2 \rightarrow CO_2}$ $\quad \cancel{\Delta H° = -282.96\ kJ}$

$\cancel{3CO} + 1.5O_2 \rightarrow \cancel{3CO_2}$ $\quad \Delta H° = -848.88$ kJ

$2Fe + 1.5O_2 \rightarrow Fe_2O_3$ $\quad \Delta H° = -822.14$ kJ

Don't forget to add states. Try 5.55, 5.57, 5.58, 5.61 (pg. 175)